Wheat Wild Relatives – A 25 Year Program of ex-situ Conservation

Yehoshua Anikster, Hanan Sela, Pnina Ben-Yehuda and Jacob Manisterski
Institute for Cereal Crops Improvement, Tel Aviv University, Tel Aviv 69978, Israel

Introduction

Recent wide-scale urbanization and road construction are of immediate danger to many populations of wild-growing relatives of crop plants in which Israel is rich, among them relatives of wheat. In most parts of the tiny densely populated Israel the ideal solution of in-situ conservation cannot be applied. A long-term project of ex-situ conservation of wild emmer and of five diploid species of Aegilops, belonging to section Sitopsis was launched in 1980.

<table>
<thead>
<tr>
<th>Table 1. Taxa collected for conservation</th>
<th>Common name</th>
<th>Genome</th>
</tr>
</thead>
<tbody>
<tr>
<td>Tritium turgidum L. subsp. dicoccoides (Forsk. ex Aeg. &amp; Griseb.) Thell</td>
<td>Wild Emmer</td>
<td>AABB</td>
</tr>
<tr>
<td>Ae. tauschii (Schwein.) Thell.</td>
<td>slender Goltzgrass</td>
<td>SSS</td>
</tr>
<tr>
<td>Ae. sharonensis Thell.</td>
<td>Sharon Goltzgrass</td>
<td>SSS</td>
</tr>
<tr>
<td>Ae. speltoides (Tausch) Nevski</td>
<td>Goltzgrass</td>
<td>SSS</td>
</tr>
<tr>
<td>Ae. speltoides (Tausch) var. speltoides</td>
<td>Goltzgrass</td>
<td>SSS</td>
</tr>
</tbody>
</table>

The goal of this project was to collect and store as large a number of genotypes as possible in each of these species. So far the collections have been used for evaluation of disease responses, salt tolerance and of molecular variation.

Methods

Sampling – With the intention of generating a maximum of genetic variation, collections of each species were made in diverse habitats and in different geographical regions. Usually, single-plant samples of one spike were taken at distances varying from 1 to 5 m between plants along linear transects. In large populations, several parallel and/or perpendicular transects were plotted. In many cases the same population was sampled during a period of several years.

Recording – Each spike was recorded as a separate accession within the population. The site of each population and the lay-out of the transects were recorded using map coordinates or, more recently, GPS instruments. Notes were taken on soil type, annual rainfall, and foliar diseases.

Propagation – A S generation of each accession in these species was raised from a single seed in each case in a nethouse in Tel Aviv University. Later generations progenies were produced on field plots for diverse tests.

Evaluations

Disease response – Seed of the original spike, as well as second-generation progenies were grown in temperature controlled greenhouse (20°C) for tests of response to artificial inoculation of seedlings with the fungal diseases: leaf rust, stem rust, stripe rust, and powdery mildew of wheat.

Molecular variation – Extracts from second generation seedling leaves were analyzed using RFLP, AFLP and microsatellite markers.

Salt tolerance – Progenies of advanced generations were used for this test.

Seed storage – The original seed of all accessions, as well as seed of progeny-generations stored in paper bags in dry storage rooms at 5-10°C and 35% RH in the Lieberman Okinow Germplasm Bank at the Institute for Cereal Crops Improvement, Tel Aviv University. At present there are 13,476 accessions of the six species in the germplasm bank.

Ammiad in-situ studies

For over two decades (since 1983) populations of wild emmer have been monitored and subjected to in-situ management at Ammiad, in Eastern Galilee. On-line studies have centered on demography, response to grazing regimes, and incidence of foliar diseases. Progenies from the site (taken annually from permanent sampling points), have been analyzed for spatial and temporal genetic variation in allotypes, subunits of storage proteins, AFLP and RFLP patterns, response to fungal pathogens, and variation in phenotypic traits. These progenies form part of our ex-situ stored collections.

Results

For example (Figure 1) a dense stand (yellow in foreground) of Ae. sharonensis. About 1 km behind it are the three chimneys of a coal-fired power station (the largest in Israel), forewarning of a sad future for this population.

Genetic variation (molecular markers)

Figure 2. Genetic diversity. % of 7 populations of Ae. speltoides based on 8 microsatellite markers. Highest He values were found in 3 populations (d, f, g) growing in bare patches in natural scrubland. The lowest genetic diversity was found in an open field in Brachia (g) the southernmost world population of this species. Within populations diversity (98%), was much higher then among populations (14%).

Figure 3. Summary of resistance responses of wild emmer (a) and 4 Aegilops species to artificial seedling inoculations with wheat leaf rust (LR), wheat stripe rust (VR) and powdery mildew (PM) of wheat. a = wild emmer; b = Ae. bicornis; c = Ae. longissima; d = Ae. sharonensis; e = Ae. speltoides. For Ae. longissima and Ae. speltoides no data of resistance to powdery mildew are shown. It is notable that Ae. bicornis (a), a desert species, shows almost total resistance to powdery mildew and no resistance to the rusts. Highest resistance to wheat leaf rust is in Ae. speltoides (c) while wild emmer (a), was highly susceptible to this rust.

% Resistant plants

Table 1. Summary of resistance responses of wild emmer and 4 Aegilops species to artificial seedling inoculations with wheat leaf rust (LR), wheat stripe rust (VR) and powdery mildew (PM) of wheat.

Population

Figure 4. Resistance responses of 8 populations of Ae. sharonensis to leaf rust, stripe rust and stem rust of wheat. With the realization that the endemic Ae. sharonensis is the most urgent candidate for conservation (Fig 1), greater emphasis has been placed on seed collections of this species in recent years. A comparison of resistance responses to rust fung of wheat – showed variation among populations of this species. Two very different resistance pictures were obtained at the southernmost populations shown here (g and h) which grow in a close vicinity in the same sandy habitat.

A. Response of 8 populations of Ae. sharonensis (a-h) to seedling artificial inoculation with wheat leaf rust, wheat stripe rust and wheat stem rust. B. Geographical location of the 8 populations on Israeli coastal plain schematic map.

Figure 5. A mixed population of wild emmer with wild barley (Hordeum spontaneum) at the Ammiad in-situ study site.

Parasitic variation – the mirror image

The great variation of the host has a mirror image – variation in the obligate parasites which evolved together with their hosts. Our research on rusts of wild relatives of wheat has led to a better understanding of their biology including discovery of new rust forms (Ben Yehuda et al. 2004).

Conclusions

Only part of the populations that we have sampled in the course of 25 years still exists today. The lost populations will be perpetuated by ex-situ conservation, if only partially.

Our studies point to considerable variation in the wild populations of each of the six species, including factors of disease resistance, (Anikster et al 2005 a,b). All collections are held in abeyance for use of evolutionary research and most importantly, by use of geneticists and breeders, now or in the future.

References